Horticulture and Agroforestry

Status of Agricultural Development in Eastern India
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CHAPTER 4.1

Horticulture Development : Current Status and Strategies

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Introduction

The eastern region of India occupies about 28% of the National geographical area and inhabited by about 35% of total population, spread over the states of Eastern UP, Bihar, Jharkhand, Odisha, Chhattisgarh, West Bengal and plains of Assam. The region is having about 1.24 times population density to that of national average. The region can be divided into three distinct geographical entities, viz. (1) Plains of Eastern UP, Bihar, West Bengal, Assam, (2) Hilly and Plateau regions of Jharkhand, West Bengal, Odisha, Chhatisgarh , and (3) Coastal plains of West Bengal and Odisha.

The climate of the eastern region is tropical, hot and humid except in hilly areas with high rainfall. The eastern plains are endowed with rich basic natural resources viz., the most fertile land and abundance of water. The average annual rainfall in this region varies from 1008 mm to 3126 mm. The mean annual rainfall over the geographical domain of Eastern UP, Bihar plateau, Bihar plains, Odisha, sub-Himalayan West Bengal, and Gangetic West Bengal is about 1008 mm, 1373 mm, 1203 mm, 1482 mm, 3126 mm and 1425 mm, respectively. Even though the region has rich rain, surface and ground water resources, they are grossly under utilized, with the result, large proportion of the cultivated area does not receive any irrigation water, and the farmers depend on the vagaries of the monsoon for crop production. As per available information only 43% of the net cultivated area in Bihar, 26% in Odisha, 22% in West Bengal and 9% in Jharkhand are irrigated as compared to 95% area irrigated in Punjab. Large tracts of cultivable land during *rabi* season remain

fallow in spite of the fact that crops in *rabi* season is relatively disease free and receive plenty of sunshine. As sizeable part of the cultivated area in eastern region do not have provision for assured irrigation, therefore, even short spell drought adversely affects the stability of agricultural production, thereby resulting in low productivity. Consequently, agriculture and horticulture development is much below its potential. As a result, the employment in agriculture sector is limited and a large proportion of the population still remains below the poverty line and suffers from malnutrition. Owing to poor utilization of water resources, the cropping intensity in the region is low (142%). Horticulture and horticulture based cropping patterns offer best land utilization option for these areas.

Nutritional imbalance caused in this region is mainly due to the lack of awareness about the nutritive values of the horticultural crops (Mahapatra *et al.* 2012). Prevalence of major diseases in Assam include Vitamin A deficiency, Anemia in children as well as women, diarrhea, fever, malaria, jaundice, tuberculosis and asthma. Number of persons per 100000 in Assam suffering from Asthma is 3278, Tuberculosis is 710, Jaundice is 2768 and malaria is 2974. Percentage of children suffering from fever is 28.4, diarrhea is 8.2 and diarrhea specifically with blood is 2.2. In Assam prevalence of anemia among women is 69.7% and among children it is 63.2%. In Bihar, including east and west Champaran districts were found to be endemic with anemia with 68.3% in women in general, 87.6% in children and 60.2% in pregnant women. In Eastern UP a prevalence of Anemia among women was found to be 51.8% and among children it was found to be 85.10% and no. of persons suffering from tuberculosis were 450 per 100000 populations. A noticeable fact that in Uttar Pradesh, 24.7% men are also reported to be anemic. In Jharkhand, the major nutritive problem prevailing is anemia in women and children due to iron deficiency and percentage of children with anemia is 77.7%.

Biodiversity in Horticultural Crops

The region is endowed with an array of native flora and economically important horticultural species. The presence of a large number of ethnic groups and inaccessibility of the area following sustenance of agriculture have contributed to the preservation of horticultural crop diversity. The different agricultural universities and ICAR Institutes have taken up the task to preserve the diversity in their gene banks.

Fruits

The eastern region has rich diversity of many fruit crops like *Mangifera indica, Anacardium occidentale, Buchanania latifolia*, *Semicarpus anacardium, Rhus semialata, Odina wodier, Spondius mangifera*, *Carica papaya, Tamarindus indica, Terminalia catapa, Terminalia chebula, Dillenia indica, Dillenia pentagyna, Dillenia aurea, Diospyros tomentosa, D. cardifolia, D.montana, Dispyros embryopteris, Flacourtia ramontchi, Flacourtia latilfolia, Flacourtia cataphracta, Flacourtia jangomus*, *Caseria tomentora, C.graveolem, Pithecelobium dulce, Punica granatum, Morus indica, Morus lavigata, Artocorpus heterophyllus, A. lakoocha, Artocarpus altilis, Ficus comosa, F.benjamina, F.glomerata, F.carica, Musa sapientum, Syzigium cuminii, Eugenia caryophylifolia, Eugenia heyneana, E.glaucissima, E.jambos, Psidium guajava, Averrhoa carambola,*

*Trapa bispinosa, Aegle marmelos, Citrus aurantium, C.media, Zizyphus mauritiana, Litchi Chinensis, Nephelium longana, Madhuka indica, Mimusops hexandra, M.elengi, Elaeocarpus floribunda, Grewia tilifolia, Carissa carandas, Annona squamosa, A.reticulata*etc. The different Universities and ICAR institutes are maintaining the field gene bank of these fruit crops. ICAR Research Complex for Eastern Region, Research Centre (ICAR RCER, RC) Ranchi is maintaining the germplasms of litchi (51), mango (250), guava (50), custard apple (20), tamarind (36), jack fruit (100), aonla (19) in its germplasm repository. Similarly, National Bureau of Plant Genetic Resources Regional Station at Ranchi and Shillong are maintaining the important and rare germplasms of few of these fruits.

Vegetables

The region is rich in diversity of various vegetables crops such as *Benincosa, Momordica, Cucumis, Trichosanthes, Cucurbita, Luffa, Coccinia, Solanum, Capsicum, Vigna, Lablab, Pisum, Colocasia, Amorphallus, Dioscoria, Abulmoschus, Amaranthus, Basella, Beta, Corriandum, Trachyspermum, Rumex, Nigella, Lepidum, Foeniculum, Euryale, Trapa, Bamboosa, Curcuma, Zingiver, Chenopodium.* A large number of varieties have been identified and developed for commercial cultivation from this large gene pool. ICAR RCER, RC, Ranchi is maintaining the germplasms of brinjal, tomato, pea, cowpea, cucumber, French bean, dolichos bean, winged bean, vegetable soybean, parwal, kundru, ridge gourd, sponge gourd, kakrol.

Medicinal and aromatic plants

The eastern region comprising the high vegetation area of Jharkhand, Chattisgarh, West Bengal and Assam is endowed with a vast genetic diversity of different medicinal and aromatic plants such as *Solanum khasianum, Cassia angustifolila, Diosocorea, Vinca*, *Bacopa, Withania, Rouwolfia, Cymbopogona, Centela, Ocimum.* Out of the large gene pool few species has been tapped by the local Baidya and are being cultivated at larger scale in the region. These includes *Andrographis paniculate*, *Aloe vera*, *Asparagus racemosus*, *Bacopa monnieri, Chamomil, Nyctanthes arbortristis, Piper longum*, *Rauwolfia serpentina, Tinospora cordifolia and Withania somnifera.*

Production Potential of Important Horticultural Crops

On the national scene horticultural crops have played important role in diversification of land use for better utilization, improvement in productivity, increase in employment opportunities, better economic return and nutritional security worldwide. Horticulture and Plantation Sector has received focused attention in our planning process from 7thfive year plan period onwards. As a result, there has not only been sustained increase in production of horticulture and plantation crops but hi tech horticulture has also been recognized as a commercial proposition. The benefit of area expansion in horticulture in clusters supported by post harvest management infrastructure has percolated down to even small and marginal farmers- a number of whom contribute to exports of horticulture produce too. Horticulture accounts for about 30% of India's agricultural GDP from 13.08% of cropped area. It also provides about 37% of the total exports of agricultural commodities. India is the second largest producer of fruits and vegetables, and the production has tripled over the last 50

years. The country produces fruits and vegetables to the tune of 71.5 and 133.7 million tonnes, respectively. However, it has been estimated that 37% of our highly perishable horticulture crops are wasted due to lack of post harvest management and cold chain infrastructure which account for an annual loss of ₹ 60000 crores approximately.

Fruits

Horticultural scenario of the eastern region is undergoing sea change in recent years. Fruits and vegetable crops cover more than 70% of the total area under horticulture. The area under fruit crop is 1.2092 M ha with an average productivity of 11.0758 t ha^{-1} compared to national average of 11.3 t ha^{-1}. The total fruit production in eastern India is 13.3931 million tonnes which contribute 18.73% of total fruit production at national level. The last five years has witnessed 28.74% increase in total area under fruits and 39.63% increase total fruit production in eastern India (Table 1). The increase in productivity in eastern India during the last five years was 10.6% as compared to 9.15% at national level. The higher rate of increase in productivity of fruit crops in eastern India can be attributed to higher rate of increase in the contribution of crops like banana (having high productivity level of 34.3140 t ha^{-1}) to the total fruit production in the eastern states as compared to national level. The productivity of major fruit crops, except litchi and pineapple, of eastern India is less than the national level. The insignificant increase in productivity of fruit crops over the last five years cannot be explained by long gestation period of new plantations only and productivity of fruits and plantation crops continue to be a matter of serious concern. This pattern of growth of productivity of fruits and plantation crops may be attributed to lack of linkage between area expansion programme and availability of quality planting materials, low productivity of old and senile plantations and lack of scheme components dealing with productivity of existing orchards in project mode through technology interventions, promotion of capital investment for infrastructure development etc.

Table 1. Area, production and productivity of fruits in eastern region during 2009-10

State	2009-10		
	Area (M ha)	Production (million tonnes)	Productivity (t ha^{-1})
Assam	0.1173	1.5755	13.4262
Bihar	0.2936	3.4649	11.8025
Chhatisgarh	0.1253	1.1859	9.4614
Jharkhand	0.0377	0.5776	15.3213
Odisha	0.3021	1.8451	6.1078
Eastern UP	0.1248	1.8830	15.0846
West Bengal	0.2083	2.8610	13.7327
Eastern region	1.2092	13.3931	11.0758
India	6.3292	71.5155	11.2992

Source: www.nhb.gov.in

Among the eastern states, the maximum area under fruit crops is in the state of Odisha (0.3021 M ha) whereas the minimum area under fruit crops is in the state of Jharkhand (0.0377 M ha). However, the state of Bihar contributes for the maximum fruit production among the eastern states (3.4649 million tonnes). The maximum productivity of fruit crops among the eastern states (15.3213 t ha^{-1}) was recorded in the state of Jharkhand. Lower productivity of fruit crops in states like Odisha and Chhattisgarh contributed towards lower average productivity of fruit crops in eastern region. With respect to individual fruit crops,

the state of Assam ranks first with respect to productivity of guava in eastern region (18.8 t ha^{-1}) whereas the state of Bihar ranks first in term of productivity of banana (45.6 t ha^{-1}). Eastern UP ranks first with respect to productivity of papaya whereas the state of Jharkhand ranks first with respect to productivity of citrus (lime and lemons) (12.4 t ha^{-1}), litchi (12.0 t ha^{-1}) and mango (16.8 t ha^{-1}). The state of West Bengal has the highest productivity of pineapple (30.5 t ha^{-1}) in the eastern region (www.nhb.gov.in).

Vegetables

At present, the area under vegetable production in eastern India is 3.9727 M ha with a total production of 64.2696 million tonnes. The average productivity of vegetable crops in eastern India is 16.1779 t ha^{-1} as compared to national average of 16.7491 t ha^{-1}. Eastern India contribute 48.06% of total vegetable production in the country. Among the eastern states, West Bengal ranks first in total area (1.3027 M ha) and production (21.9065 million tonnes) of vegetable crops. However, Eastern UP ranks first in terms of productivity of vegetable crops (21.9937 t ha^{-1}). Among the major vegetables of Eastern UP, the maximum productivity was recorded in cabbage (22.9372 t ha^{-1}). Last five years have witnessed 5.99% increase in area under vegetable crops and 13.78% increase in production of vegetable crops in eastern India (Table 2). The productivity increase during the last five years in eastern India is 7.35% as compared to 6.84% at national level. This can be attributed to large-scale introduction of improved varieties of different vegetable crops along with high input based production technologies by the farmers. Share of potato to total vegetable crop production in eastern India is maximum. Hence, higher contribution of crops like potato (having high productivity level of 19.9021 t ha^{-1}) to total vegetable production in eastern India can also be attributed to higher rate of increase in average productivity of vegetable crops in eastern India over that at national level. It is also noteworthy that vegetable production has recorded increase in spite of the fact that these crops have not been substantially covered under schemes of NHM, TMNE and NHB.

Table 2. Area, production and productivity of vegetables in eastern region during 2009-10

State	2009-10		
	Area (M ha)	Production (million tonnes)	Productivity (t ha^{-1})
Assam	0.2552	4.5699	17.9056
Bihar	0.8360	13.9068	16.6345
Chhatisgarh	0.3154	3.6011	11.4177
Jharkhand	0.2121	3.4692	16.3571
Odisha	0.6942	8.9636	12.9117
Eastern UP	0.3570	7.8525	21.9937
West Bengal	1.3027	21.9065	16.8165
Eastern region	3.9727	64.2696	16.1779
India	7.9848	133.7376	16.7491

Source: www.nhb.gov.in

With respect to individual vegetables, Eastern UP ranks first with respect to productivity of brinjal (30.64 t ha^{-1}), cabbage (30.86 t ha^{-1}), tomato (39.0 t ha^{-1}), potato (24.9 t ha^{-1}) whereas Jharkhand ranks first with respect to productivity of okra (14.0 t ha^{-1}), peas (14.0 t ha^{-1}) and onion (20.0 t ha^{-1}). West Bengal has the highest productivity of cauliflower (25.35 t ha^{-1}) in eastern region.

Flowers

With respect to flower crops, the total area in eastern India is 0.0385 M ha with a total production of 0.1245 million tonnes of loose flowers and 3028.35 million numbers

of cut flowers. Eastern India contributes 12.2 and 45.42% of total loose flowers and cut flowers, respectively, produced in the country. The state of West Bengal is the leading state in eastern India in terms of area and production of both loose and cut flowers. In last five years, area under floriculture crops increased by 59.14% in eastern India as compared to 41.31% at national level whereas the production of loose flower and cut flower increased by 129.72% and 175.10%, respectively in eastern India as compared to 53.11% and 117.03%, respectively at national level. There exists ample opportunity for the development of floriculture in the region.

Spices

With respect to spices, eastern India contributes 12.60% of total spice production in the country with a total production of 0.4814 million tonnes. The major spices produced in the region are ginger, chilli, garlic, turmeric, coriander, fennel, fenugreek, cardamom (large). During the last four years, the spice production in eastern India increased by 17.36% and 5.45% increase in area under spices. At national level the increase in spice production during the last five years was 8.4% with 4.1% increase in area under spices. Among the eastern states, the maximum spice production was recorded in Odisha. However, the increase in area and production during the last four years can mainly be attributed to significant increases in the state of West Bengal (21.35% increase in area and 64.82% increase in production). The increases in other states have been meagre or in negative side. Among all the spices, contribution to the total production is maximum in case of ginger (30.64%) followed by chilli (24.65%) and garlic (22.08%) (Fig. 1).

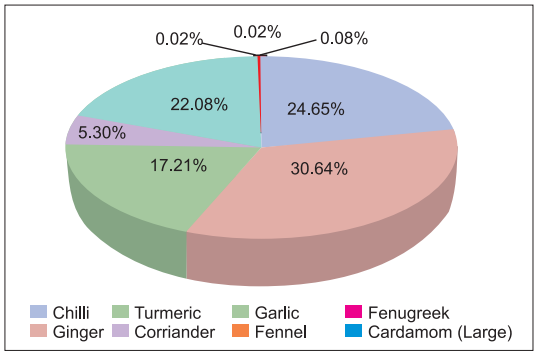


Fig. 1. Share of different spices to total spice production in eastern India (2006-07)

Medicinal plants

In case of medicinal plants, the total area and production in eastern India is 0.1473 M ha and 0.0789 million tonnes, respectively. Out of all the eastern states, Chattisgarh contributes 87.07% of total production (Fig. 2) whereas Eastern UP contributes towards 87.31% of total area under medicinal and aromatic plants. With respect to aromatic plants, the last five years have witnessed 97.8% increase in area and 554% increase in production in the eastern region as compared to 93.6% and 170.5% increase in area and production, respectively at national level. The large scale increase in

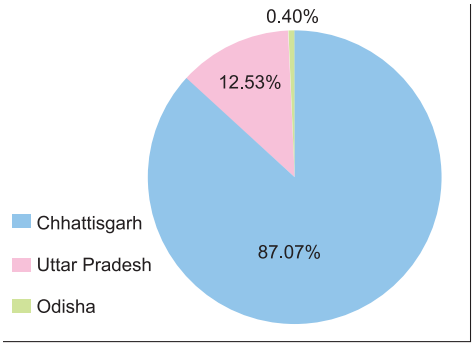


Fig. 2. Share of different states on total production of medicinal and aromatic plants in eastern India (2009-10)
***Source*: www.nhb.gov.in**

production of aromatic plants can be attibuted to 605.04% increase in area and 808.94% increase in production in the state of Chhatisgarh.

Plantation crops

With respect to plantation crops, the total area in eastern region is 0.3668 M ha with a total production of 0.7309 million tonnes (Table 3). Eastern India contributes only 6.12% of total production of plantation crops in India. The major plantation crops of the region are Cashew nut, Coconut and areca nut. Among the eastern states, the maximum area under plantation crops is in Odisha whereas West Bengal ranks first in terms of total production. There is vast scope for expanding areca under cashew in Chattisgarh and non traditional areas of Jharkhand. Similarly, there is scope for large scale expansion of area under oil plam in states like Odisha and Assam. Betel vine is an important commercial crop in the region, and the region has excellent cultivars for commercial exploitation. The crop provides livelihood to a large number of small and marginal farmers, as it has potential to give higher income per unit of land. However, in the traditional system of cultivation, yield is low and the problem is faced due to incidence of a number of diseases.

Table 3. Area, production and productivity of plantation crop in eastern region during 2009-10

State	2009-10		
	Area (M ha)	Production (million tonnes)	Productivity (t ha^{-1})
Assam	0.0888	0.1637	1.8441
Odisha	0.1940	0.2740	1.4124
West Bengal	0.0510	0.2762	5.4160
Eastern India	0.3668	0.7309	1.9927
India	3.2646	11.9282	3.6538

Source: www.nhb.gov.in

Projected Requirement of Horticultural Crops

Considering 30% post harvest loss, the total availability of fruits in eastern region is 9.3752 million tonnes. Hence, the per capita availability (total population of 389.37 million) of fruits in eastern region is about 65.96 g/day which is much below the dietary requirement of about 120 g/day. The present requirement of total fruit production to meet the minimum dietary requirement is 17.0542 million tonnes. Considering a population of 448.3210 million in eastern India by the year 2026, the total fruit requirement in eastern India will be 24.5455 million tonnes (with post harvest loss of 20% considering improved scenario of post harvest management of fruits and vegetables). To meet the gap, an additional area of 0.8621 M ha has to be brought under fruit cultivation considering increase in productivity to level of 12.0 t ha^{-1} from the existing level of 11.07 t ha^{-1}. This will require about 344.84 million numbers of quality saplings.

At present the total vegetable availability in eastern India, considering a post harvest loss of 30%, is 44.9887 million tonnes. Hence, the per capita availability of vegetables in eastern India is 316.56 g which is above the minimum dietary requirement of 300g. Hence, the total vegetable requirement in eastern region is 42 million tones approximately. At national level, there is a deficit of 38.67 million tonnes of vegetables to meet the minimum dietary requirement of entire population at present level of post harvest losses. The total

vegetable requirement to meet the minimum dietary requirement of eastern India by 2026 will be 61.3639 million tonnes only (with post harvest loss of 20% considering improved scenario of post harvest management of fruits and vegetables). Hence, the region can play a major role to fulfil the vegetable demand at national level. For this, there will be urgent requirement to strengthen infrastructure on handling and transportation of vegetables from this region to other part of the country.

Technological Options for Increasing Productivity of Horticultural Crops

Horticultural crops provide suitable alternative for improving the land use efficiency, and profitability of agriculture production system as well as ensuring nutritional security. The eastern region of India is endowed with climatic conditions for successful cultivation of a wide range of horticultural crops. Among the different horticultural crops, the average productivity of fruit crops is 11.0 t ha^{-1} compared to national average of 11.3 t ha^{-1}. Similarly, the average productivity of vegetable crops in eastern India is 16.1 t ha^{-1} as compared to national average of 16.7 t ha^{-1}. With respect to plantation crops, the average productivity of eastern India is only 1.9 t ha^{-1} as compared to 3.6 t ha^{-1} at national level. Use of improved production technologies in horticultural crops can help in minimizing the productivity gap. Presence of different ICAR institutes and SAUs in the eastern region has resulted in development of a number of improved technologies in horticultural crops

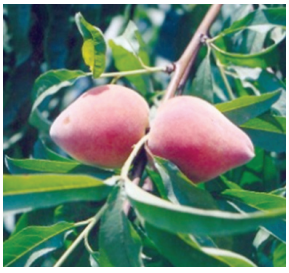
Mango variety Himsagar


Jack fruit variety Swarna Poorti


Litchi variety Shahi


Sapota variety Murabba


Strawberry variety Douglas


Peach variety Florda Sun

which can increase the productivity of horticultural crops in the eastern region. The different horticultural technologies recommended for the region are as follows.

Crops	Genotypes
Mango	Early-Bombay Green, and Zardalu; Mid early-Himsagar, and Kisanbhog; Mid Season-Langra, Safeda Malda, Dashehri, Prabha Shanker; Mid late-Mahmood Bahar and Mallika; Late-Amrapali, Bangalora; Hybrids-Alfazli (Alphonso x Fazli), Jawahar (Gulab Khus x Mehmood Bahar), Menaka (seedling selection of Gulab Khus), Safari (Gulab Khus x Bombay), Subhash (Seedling selection of Zardalu) and Sundar Langra (Langra x Sundar Pasand), Arka Neelachal Kesari,
Litchi	Early-Shahi, Ajhauli, and Green; Mid-Swarna Roopa, Rose Scented and Early Bedana; Mid late-CHES-2, China, Purbi and Late Bedana; Late-Kasba and Dehradun; Fragrant pulp-Shahi and Rose Scented; Small Seeded-Late Bedana, Early Bedana,; Hybrid-Sabour Madhu (Purbi x Bedana)
Guava	High yield-Sardar and Allahabad Safeda; Soft seeded-Arka Mridula
Banana	Table type-Dwarf Cavendish, Alpan, Malbhog; Vegetable type-Bhos, Battisa and Muthia
Pineapple	Kew and Queen
Sweet orange	Kodur Sathgudi, Jaffa, Malta
Mandarin	Nagpur Santra, Khasi Mandarin and Kinnow mandarin
Aonla	NA-6, NA-7, Kanchan, Balwant and Chakaiya
Passion fruit	Kaveri
Custard apple	Balanagar and Arka Shahan
Papaya	CHES-1, CHES-2,CHES-3, Pusa Delicious, Pusa Giant, Pusa Dwarf, Pusa Majestic and CO-2
Ber Cashew nut	Gola, Banarasi Karaka and UmranJhargram-1, BLA-39-A, V-5, V-6, Indira Kaju, Bhubaneswar 1, BPP-8, Dhana, Jagannath, Balabhadra
Sapota	Murraba, Kalipatti
Strawberry	Douglas

Swarna Shyamali

Swarna Pratibha

Swarna Shobha

Swarna Abhilambh

Improved varieties/genotypes of fruit crops

Jack fruit cultivars Swarna Manohar and Swarna Poorti

Jack fruit is widely grown in different parts of the eastern region. However, due to lack of suitable released variety, commercial cultivation of jack fruit is non-existent in the eastern region. Keeping this in view, the jack fruit cultivars Swarna Manohar and Swarna

Poorti have been released by ICAR-RCER. The variety Swarna Manohar is suitable for table purpose. The fruits are of uniform shape with an average fruit weight of 13-15 kg having attractive skin colour. The flakes are firm containing high quality sweet fragrant pulp (TSS 20.0^0B, titratable acidity (0.09%). On an average a plant yields 500 to 550 kg fruits per tree. The fruit matures during mid-May. The variety Swarna Poortis suitable for culinary purpose. The fruits are of roundish and uniform shape, medium sized (average fruit weight 3 to 5 kg) having attractive green skin colour. On an average, a plant yields 100 to 120 kg fruits per tree. The availability period of fruits is from March to July.

Improved varieties/genotypes of other fruit crops

Different genotypes of other fruit crops found promising for cultivation in the eastern region are given below.

Improved varieties of vegetable crops

(a) Bacterial wilt resistant high yielding varieties of brinjal

Swarna Pratibha produces long fruit (15-20 cm) having shiny purple colour. Average fruit weight is 150-200 gm. It also possesses excellent cooking quality. The yield potential is 60-65 t ha^{-1} and is resistant to bacterial wilt.

Swarna Shyamli produces round (200-250 gm) stripped green with purple Colour fruit. The yield potential is 60-65 t ha^{-1} and is resistant to bacterial wilt.

Swarna Shobha produces round (300-350 g) medium sized attractive milky white with purple tinge fruits. The yield potential is 50-60 t ha^{-1} and is resistant to bacterial wilt.

Swarna Abhilambh produces long (30-35 cm) fruits weighing 80-100 g having attractive purple colour. The yield potential is 65-70 t ha^{-1} and is resistant to bacterial wilt.

Swarna Mani produces attractive, shiny purple in colour, round in shape. The yield potential is 40-50 t ha^{-1} and is moderately resistant to bacterial wilt.

(b) Bacterial wilt resistant F_1 hybrids of brinjal

Swarna Shakti produces medium long (15-17 cm) fruit with shiny light purple colour. The yield potential is 70-75 t ha^{-1} and is resistant to bacterial wilt and phomopsis blight.

Swarna Ajay produces oblong fruit with attractive light purple colour. The yield potential is 70-75 t ha^{-1} and is resistant to bacterial wilt and phomopsis blight.

Swarna Neelima produces round fruits with attractive purple black colour. The yield potential is 80-90 t ha^{-1} and is resistant to bacterial wilt and phomopsis blight.

(c) Bacterial wilt resistant high yielding varieties of tomato

Swarna Lalima is a determinate variety producing round (120-125 g), deep red fruits in cluster of 3-4. The yield potential is 60-70 t ha^{-1} and is resistant to bacterial wilt.

Swarna Naveen is an indeterminate variety producing oblong (60-70 g), deep red fruits borne in cluster of 8-10. The yield potential is 60-65 t ha^{-1} and is resistant to bacterial wilt.

Swarna Samridhi

Swarna Sampada

Swarna Vijaya

Swarna Deepti

(d) Bacterial wilt resistant F_1 hybrids of tomato

Swarna Samridhi produces round (70-80 g), red, firm fruits in cluster of 8-10. The variety is suitable for processing industry. The yield potential is 100-105 t ha^{-1} and is resistant to bacterial wilt and early blight.

Swarna Sampada produces round (120-130 g), red, firm fruits in cluster of 4-5. The yield potential is 100-105 t ha^{-1} and is resistant to bacterial wilt and early blight.

Swarna Vijaya has round shaped fruit, red, weight (80-90 g), firm, TSS 4.5-5.0°B, acidity 0.35-0.40% and containing high pulp. The hybrid is resistant to bacterial wilt and early blight. Average yield is 90-100 t ha^{-1}.

Swarna Deepti produces round, red fruits (120-130 g), firm, TSS 4.5-5.0°B, acidity 0.35-0.40% and containing high pulp. The hybrid is resistant to bacterial wilt and early blight. Average yield is 100-105 t ha^{-1}.

(e) Swarna Baibhav-Promising F_1 hybrids of tomato

Swarna Baibhav produces round (140-150 g), deep red, firm fruits in cluster of 3-4, yield 9-10 t ha^{-1}. It is suitable is suitable for distant market and processing. Suitable for main season cultivation.

(f) HATH-10: Bacterial wilt resistant indeterminate type F_1 hybrid of tomato suitable for protected cultivation

The F_1 hybrid is indeterminate in growth habit, high yielding (187.79 t ha^{-1}), resistant to bacterial wilt, plant height 5.5 m, fruit weight 80 g. Transplanting is done in middle of August and first harvest is obtained from 70-80 days after transplanting. Harvesting period range from 180-200 days. The hybrid is suitable for protected cultivation in bacterial wilt prone areas.

Survival of plants of HATH-10 against bacterial wilt

(g) Swarna Poorna, Swarna Ageti and Swarna Sheetal-promising cucumber varieties

Swarna Poorna fruits are cylindrical long in shape, medium size (300 g), light green colour with no placental hollowness and is tolerant to powdery mildew. The yield potential is 30-40 t ha^{-1}.

Swarna Ageti fruits are cylindrical long in shape, medium size (200 g), green colour with no placental hollowness also tolerant to powdery mildew. The yield potential is 30-32 t ha^{-1}.

Swarna Sheetal fruits are cylindrical long in shape, medium size (250 g), green colour with no placental hollowness also tolerant to powdery mildew. The yield potential is 25-30 t ha^{-1}.

Swarna Poorna

Swarna Ageti

Swarna Sheetal

(h) Swarna Manjari and Swarna Uphar: Improved varieties of Ridge gourd

Swarna Manjari produces long (15-20 cm.) highly ridged and green fruits. The pulp is very soft and contains less fiber. The yield potential is 18-20 t ha^{-1}.

Swarna Uphar produces long (15-20 cm), low ridged and green fruits. The pulp is very soft and contains less fiber. The yield potential is 20-30 t ha^{-1}.

Swarna Manjari

Swarna Uphar

(i) Swarna Prabha (released in 2006) : Improved variety of Sponge gourd

Swarna Prabha produces long (20-25 cm.) smooth and light green fruits. It is tolerant to powdery and downy mildew and resistant to leaf minor under field condition. The yield potential is 20-25 t ha^{-1}.

Swarna Prabha

(j) Swarna Amrit : Improved variety of Pumpkin

Swarna Amrit has an average fruit weight 2.5-3.0 kg. It is round flat in shape and fruit colour is green. It is recommended for kharif and summer season cultivation. It gives an average yield of 4.5-5.0 t ha^{-1} and it is highly suitable for table purpose.

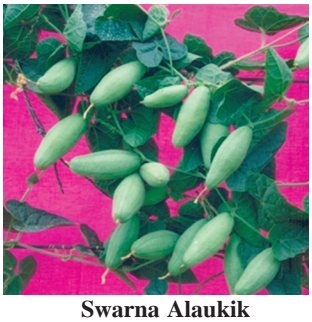
(k) Swarna Rekha, Swarna Alaukik, Swarna Suruchi : Improved varieties of pointed gourd

Swarna Rekha bears elongated (30-35 g), striped green fruits and contain soft seed. The yield potential is 30-35 t ha^{-1}.

Swarna Alaukik bears cylindrical (25-30 g) and light greenish fruits. The yield potential is 25-30 t ha^{-1}.

Swarna Suruchi bears cylindrical (35-40 g) and light greenish fruits without stripes. The yield potential is 25-30 t ha^{-1}.

Swarna Rekha



Swarna Alaukik

Swarna Suruchi

(l) Swarna Amar and Swarna Mukti : Improved mid-season garden pea varieties

Swarna Amar produces long (10 cm), concave, acute apexed, thin walled and dark green pods with >50% recovery of dark green shelled peas having excellent taste & cooking quality. The yield potential is 22 t ha^{-1} and is resistant to powdery mildew. The variety is suitable for mid and late winter season cultivation in plains.

Swarna Mukti produces medium long (9.25 cm), mildly concave, obtuse apexed and light green pods with 50% recovery of light green shelled peas having excellent

Swarna Amar

cooking quality and taste. The yield potential is 20 t ha^{-1} and is resistant to powdery mildew. The variety is suitable for mid and late winter season cultivation in plains.

(m) Swarna Sweta, Swarna Harita, Swarna Suphala and Swarna Mukut: Improved varieties of vegetable cowpea

Swarna Sweta produces straight, round, whitish coloured and fleshy pods having very good cooking quality. The yield potential is 27 t ha^{-1} and is suitable for summer and *kharif* season cultivation.

Swarna Harita produces straight, dark green, very long (50-60 cm), fleshy pods having excellent cooking quality. Yield potential is 31 t ha^{-1} and is suitable for summer and *kharif* season cultivation.

Swarna Suphala produces light green, straight, round (bulged at seed position) and fleshy pods having very good cooking quality. Yield potential is 24 t ha^{-1} and is suitable for summer and *kharif* season cultivation.

Swarna Mukut produces light green, straight, round and fleshy pods. Pods are rich in protein, vitamins and minerals. Yield potential is 15 t ha^{-1} and is suitable for summer and *kharif* season cultivation.

Swarna Mukti

Swarna Suphala

Swarna Harita

Swarna Sweta

(n) Swarna Priya and Swarna Lata : Improved French bean varieties

Swarna Priya is bush type variety that produces flat, green straight, stringless and fleshy pods. The yield potential is 13 t ha^{-1} and is suitable for spring-summer and autumn-winter season cultivation.

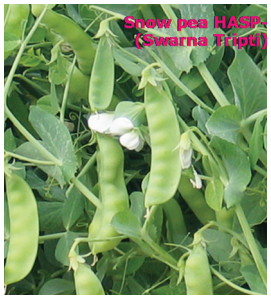
Swarna Lata is pole type variety that produces stringless, round, green and fleshy pods. The yield potential is 15 t ha^{-1} and is highly suitable for rainy and autumn-winter season cultivation.

(o) Swarna Utkrisht and Swarna Rituvar : Improved dolichos bean variety

Swarna Utkrisht is pole type varietythat produces straight, flat, green and fleshy pods having very good cooking quality. The yield potential is 28 t ha^{-1} and suitable for autumn-winter season cultivation.

Swarna Rituvar is a pole type lablab bean variety suitable for off-season cultivation, producing creamy white and flat pods. The yield potential is 15 t ha^{-1} and is suitable for off season cultivation.

Swarna Utkrisht



Swarna Tripti

Swarna Lata

Swarna Priya

Swarna Rituvar

(p) Swarna Tripti: Improved snow pea variety

The pods are fibre less and very flat. The whole pod is sweet and edible. The variety is resistant to powdery mildew and average pod yield is 24-28 t ha^{-1}.

(q) Swarna Vasundhara : Improved vegetable soyabean variety

Pods are 2 and 3 seeded, recovery of fresh green seeds > 50%, average fresh pod yield 15-20 t ha^{-1}.

Other improved varieties / genotypes of vegetables

The varieties of vegetable crops recommended from other centres in eastern region are given below.

Crops	Genotypes
Tomato	Vaishali, Utkal Pallavi, Kashi Amrit, Kashi Vishesh, Kashi Anupam, Kashi Hemant, Kashi Sharad, ARTH-4, ARTH-3, Gulmohar, KS-17, Utkal Uvashi, Utkal Pragyan, Sel-7, Arka Saurav, Arka Vikas, Punjab Chuhara, Punjab Kesri, Pusa Early Dwarf; Hybrid - ARTH -4, Pusa Hybrid-2 and Utkal Raja
Brinjal	Arka Navneet, Utkal Tarini, Utkal Keshari, Pant Rituraj, Mukta Keshi, Green Long, Kashi Prakash, Kashi Taru, Kashi Sandesh, AS-331, PLR-1, Azad Brinjal-2, Punjab Barsati, H-8, NDB-25, H-7, Azad Kranti, Pant Samrat, Pusa Kranti; Hybrids- Pusa Hybrid-6, Pusa Hybrid-5, ARBH-201, NDBH-1, ABH-1, MHB-10, MHB-39, NDBH-6 and ABH-2, Punjab Sada Bahar, BBL-11, JNDBL-1, KS-227, Kashi Ganesh
Capsicum	Arka Gaurav, Arka Mohini, Arka Basant and California Wonder
Chili	Arka Lohit and Pusa Jwala
Cabbage	Pride of India, Golden Acre, Pusa Drumhead, Shree Ganesh Gol, BSS-31, Selection-8, Quists, Nath-401 and Pusa Synthetic
Cauliflower	Early Kunwari, Maghshobha, Pusa Deepali, Deepalika, Improved Japanese, Pusa Snowball K-1, Pusa Snowball-16, Early Synthetic, Line-6-1-2-1, K-1 and Synthetic-1
Okra	Arka Anamika, Arka Abhay, Parbhani Kranti, Punjab-7, PB-57 and HRB-9-2, Punjab Padmini, Utkal Gaurav, Kashi Pragati, Kashi Vibhuti, Kashi Saatdhari, Kashi Bhairav, Kashi Mangali, Kashi Mahima, Kashi Mohini
Pea	Arka Ajit, NDVP-1, NDVP-5, Azad P-1; NDVP-10, NDVP-8, Vivek-6, Ageta-6, VL Ageti Matar-7, VL Matar -3, Arkel, Kashi Udai, Kashi Shakti, Kashi Mukti, Kashi Nandini

French bean (Bush type)	Arka Komal, Pusa Parvati, Pant Anupama and VL Boni-1
French bean (Pole type)	Birsa Priya and Kentucky Wonder
Cow pea	Pusa Barsati, Arka Garima, Sel-263, Sel-2-1 and IIHR-6
Parwal	Arka Neelachal Kirti
Watermelon	Arka Manik, Arka Jyoti and Sugar Baby
Ivy Gourd	Arka Neelachal Kunkhi, Arka Neelachal Sabuja
Cucumber	Priya and Pusa Sanyog
Bottle gourd	Arka Bahar, Pusa Summer Prolific Long, Pusa Summer Prolific Round and PBOG-1
Bitter gourd	Arka Harit, Priya, Kalyanpur Sona, MC-84, Pusa Hybrid-1, RHRBG-4-1 and KBG-16
Spine Gourd	Arka Neelachal Shree
Pumpkin	Arka Suryamukhi, Arka Chandan, CM-14 and Pusa Biswas
Muskmelon	Durgapura Madhu, Pusa Madhuras, Hara Madhu and Pusa Sarbati
Sponge gourd	Pusa Chikni and Selection-99
Onion	Arka Niketan, Agri found light Red, Punjab Red Round, Agri found Dark Red, Arka Kalyan, Line 102 and Pusa Red
Garlic	G-282, G-50, G-1 and G-41

Improved variety of tuber crops

Crops	**Variety/Genotypes**
Sweet potato	Gauri, Sjankar, Sree Bhadra, Pusa Safed, Sree Ratna, Kadma Local, Rajendra Shakarkand, Kalmegh, Samrat, Pusa Safed, Kisan, Kalinga, Muktakesi
Elephant Foot Yam	Gajendra, Kovvur
Colocassia	Satmukhi, Nadia Local
Yam	Sree Lata
Mishri Kand	Rajendra Mishri Kand
Cassava	H-3641

Improved variety in spices and plantation crops

Crops	**Variety/Genotypes**
Turmeric	Rajendra Sonia,
Corrainder	Pant Haritima, Rajendra Swati
Fenugreek	Rajendra Abha, Rajendra Kanthi
Fennel	Rajendra Saurav
Ajowan	Rajendra Mani
Nigella	Rajendra Shyama
Bettle vine	Culcuttia, Bangla, Ghanaghatte, Maghi

Improved Production Technologies

Fruit based multitier cropping system for uplands

The technology on fruit based multitier cropping system comprise of planting of fruit trees with large canopies (Mango, Litchi, Aonla, Jack fruit) at a spacing of 10 m x 10 m as main crop, planting of precocious bearing fruit species with dwarf canopy (guava, custard apple, lime, lemon) at a spacing of 5 m x 5m between rows and between plants in the same field as filler crop and growing of inter crops in the inters paces. The system accommodates 100 large size trees and 300 small sized trees per ha. During the initial years any kind of inter crops can be grown. After the plants of main crop attain full canopy size, the filler plants can be removed and shade tolerant inter crops like turmeric, ginger, elephant foot yam can be grown. A productivity level of 12.0 tonnes per ha of paddy equivalent yield can be obtained from 10 year old fruit based multitier system under the eastern plateau conditions.

Mango based multitier cropping system

The experiment conducted to standardize suitable filler crop and inter crops under mango based multitier system under rain fed conditions during the pre-bearing stage of main crop. The Mango plants of cv. Langra planted at a spacing of 10 x 10 m as main crop and among filler plants short stature fruit species (guava and lime) and fast growing timber species, i.e., *Gmelina arborea* (gamhar) planted at 5 m apart between and within the rows of main plants after establishment of the main plants. The inter crops like leguminous vegetables (Cow pea, French bean), suitable grass species (*Stylosanthes hamata*) and local staple food species (upland paddy) were grown in different combinations.

With respect to plant growth of mango plants, the minimum tree volume was recorded in case of fallow. In case of gamhar, the maximum plant growth (height and trunk girth) was recorded in case of inter cropping of paddy. In case of content of organic carbon in the soil, marked differences among the different inter crops could not be recorded at both 0-30 cm layer and 30-60 cm layer of soil. However, in case of fallow fields, markedly higher content of organic carbon could be recorded at top 0-30 cm soil layer over that of 30-60 cm soil layer. Among the different combinations, the maximum cumulative paddy equivalent yield of 51.24 t ha^{-1} was recorded in case of Mango+ Guava+ French bean. Among the different filler plants, guava was found to be the most promising. After 12 year of planting, drastic reduction in the yield of inter crops could be noticed which indicated the need to shift towards other shade tolerant crops. Under adult bearing mango trees, turmeric was found to be the most profitable inter crop.

Litchi based multitier cropping system

A trial was conducted under Ranchi conditions to identify suitable inter crops under litchi based multitier system with guava as filler crop during the pre-bearing stage of main crop. The different inter crops like Cow pea, French bean, Niger and Horse gram were grown in the inters paces. Inter cropping did not show any marked adverse effect on mean monthly increment in the height of plant, girth of trunk and area of canopy spread of main crop as well as filler crop. Fruit yield of filler crop was (guava) also not influenced

by inter cropping. Among the inter crops, cow pea was found to be the most profitable (₹24,000/ha). After six years, drastic reduction in the yield of all the inter crops could be observed due to the shading effect of main and filler crops. At the end of 8th year, the cow pea continued to record its supremacy as an inter crop through performing poorly, over other inter crops and yielded 3.03 t ha^{-1} green pods. Keeping this in view, inter cropping of cow pea was recommended under the litchi based multitier cropping system up to the initial 8 years of the orchard. Afterwards, inter cropping of shade tolerant crops like ginger, turmeric and elephant foot yam can be followed.

Aonla based multi-storied cropping system

Aonla has sparse foliage which allows 87.5% area for inter cropping during the initial 10 years. The experiment was initiated to standardize suitable inter crops in aonla based multitier system with guava as filler crop during the pre-bearing stage of main crop grown under rainfed conditions. Different inter crops like paddy, finger millet, Deenanath grass, black gram and ground nut were grown in the inter spaces. During initial years, no adverse effect of inter crops on main and filler crops and *vice versa* was observed. After nine years of planting, none of the treatments differed significantly with respect to the plant growth parameter of main and filler crops. After 10 years of establishment of the system, the maximum cumulative paddy equivalent yield was recorded (41.89 t ha^{-1}) in case of inter cropping of Deenanath grass in aonla based multitier system. The cumulative paddy equivalent yield of other cropping systems was at par. In all the combinations, the yield of filler crops contributed the highest proportion of total paddy equivalent yield of respective systems. Drastic reduction in the yield of inter crops could be recorded after 10 years which warranted severe pruning of mango plants. With respect to plant growth parameters, significant effect of different cropping systems could be recorded on plant volume of guava which was the maximum (44.48 m^3) in case of inter cropping of paddy. With respect to soil properties, the different cropping systems differed significantly with respect to their effect on available potassium in both 0-15 cm soil layer and 15-30 cm soil layer and available P in 0-15 cm soil layer. Inter cropping of Deenanath grass or Ragi resulted in significant increase in the content of potassium (317.18 and 312.36 kg ha^{-1} K, respectively) in 0-15 cm soil layer whereas the content of P was the maximum in case of inter cropping of Ground nut (12 kg ha^{-1} P) in 0-15 cm soil layer.

Aonla + Guava based multitier system

Horticulture based agro-forestry system for Coastal agro-eco system

Fruit crop based agro-forestry system is a multi-pronged programme of land use to meet various needs and could be ideal for restoration of ecological balance, improvement

in farm income and minimization of soil fertility depletion and loss of soil through erosion. The approach should be to increase production by exploiting the complementary effects of component crops. Fruit crop based agro-forestry system has its own merits and limitations. If practiced properly, it could be a viable alternative to both agriculture (in a broad sense) and forestry in certain specific situations. The demand for forest produce has increased further during recent years with an explosion of forest based industries such as paper, plywood, ploy-fibers and match wood. Over exploitation and degradation of vegetative cover has partially led to severe soil erosion problems in the area in addition to decline in agricultural production. The main aim of agro-forestry in west coast ecosystem is to combat soil erosion problems (Nadagoundar, 1986). For soil conservation, live bunds of subabul (*Leucaena leucocephala*), *Calliandra callothyrsus*, *Sesbania rostrata*, perennial grasses and legumes together, agave (*Agave americana*) etc. are promising. Combination of papaya with teak and arable crops has been found more productive than growing arable crops alone. The agro-forestry systems have given an additional income of ₹ 4629 to 6576 per year. Fruit crop based agro-forestry systems have given benefit: cost ratio of 11.13 as against 9.48 in arable crops. Average compound income, Net Product Value (NPV) and IRR (Internal Rate of Return) have been highest with arable crops + teak + papaya (Nadagoundar *et al.*, 1993).

Inter-cropping in plantation crops and commercial crops coffee, tea, cardamom, etc. under shades of trees are the other agro-forestry practices followed commonly in the coastal region.

Areca nut based farming system

Mixed cropping in area nut gardens has been practiced for long. Farmers inter-crop areca nut with banana, betel vine, black pepper, pine apple, cassava, *Dioscoria* spp., and *Colocassia* etc. Some progressive farmers in Kerala and Karnataka grow cocoa, nutmeg and clove in areca nut plantations. Several studies have revealed that scientific inter-cropping has positive effect on yield of areca nut. Apart from supplementing the income from the inter-crops, there is higher income from the main crop because of the complementary relationship between areca nut and the inter-crops (Das, 1991). In arecanut + Black pepper based agro-forestry system, the arecanut garden spaced at 2.7 m x 2.7 m allowed about 43% sunlight for the component crops. Rooting pattern revealed that arecanut palms planted at 2.7 x 2.7 m spacing could use effectively only 30 per cent of the land area. Crops like banana, tapioca, black pepper, colocassia, yam, pine apple can be grown as inter/mixed crop in arecanut gardens. However, pepper can be recommended as a suitable mixed crop along with areca in North Bengal as it was found to be the most productive crop in north Bengal situation. The Arecanut Var. Mohitnagar and of Black pepper varieties Panniyur-1, Panniyur-11, Subhakara, Sreekara, Karimunda are suitable for this agro based cropping system.

Coconut based inter-cropping system

Many enterprising farmers have augmented the total income by following appropriate inter-cropping from coconut based cropping system in coastal regions of India. Such cropping system provides multiple sources of income to the growers. This way the cropping

system is diversified and becomes less susceptible to degradation. The coconut trees permit cultivation of many crops under it. In a full grown up coconut plantation with 7 to 7.5 plant spacing, about 75% of the land remains under utilized because maximum root activity is up to a radius of two meters from the base of the palm.

Initially up to three years after planting and also after 20 to 24 years after planting, there is insufficient shade which allows growth of many crops under the coconut plant canopy. And even during 3 to 25 years of plantation age, some shade tolerant plants can be planted and vacant inter-spaces efficiently utilized for inter-cropping/ multi-storied cropping. Intensive inter-cropping and mixed cropping are also possible in newly established plantations. The planting is done at little wider distance say 8 x 10 or 10 x 10 m distance and fruit and high value crops are inter-cropped in such a way that these fully use distinct layers of soil and atmosphere without competing with each other for nutrients, water or sunlight. Mixed farming possesses clear cut agronomic and socio-economic advantages and is gaining importance as a method of augmenting income particularly in coastal eco-system.

The *Acacia mangium* based agro-forestry system is the most preferred fast growing MPT either in block or in paddy field bund plantation in rainfed uplands of coastal Odisha. It can attain a height of 20 to 25m within 10 years of growth. Because of its fast growth and its decorative grains in wood it is preferred by furniture, plywood and packaging industries.

The *Acacia mangium* performed better and found most suitable for Coastal Odisha condition. It is suitable for Rainfed uplands of coastal Odisha. The crop geometry to be followed as rectangular system (more spacing between rows and lesser between trees). Rows are drawn in east-west direction. This system produces a minimum of 5-6 ft. of quality log in 10 years and 580 kg ha^{-1} $year^{-1}$ Sesamum up to 6^{th} year. It gives worth ₹ 2500-3000 from wood in 10 years. In addition Sesamum can be successfully grown in the alleys of 8 m x 2 m of *Acacia mangium* during *kharif* season with a yield of 580 kg ha^{-1} seed and yield recovery of 70-75% up to 60 months of planting of tree species and substituted by shade loving crops like turmeric and arrowroot afterwards with a B: C ratio of 2.12. Arrowroot (yield 5.20 t ha^{-1} and B:C ratio 1.73) and Turmeric (4.14 t ha^{-1} and B:C ratio 1.66 can be profitably taken up with 5 year old *Acacia mangium* and mango plantation in Agri-silvi-horti agro-forestry system under rain fed condition of Odisha. It provide multiple products of timber, fruit and agriculture and it is environmentally sustainable and can be used by both small and large farmers.

Acacia mangium based agro forestry system

Home Gardens

The home gardens are common features of fruit crop based agroforestry systems in coastal ecosystems of India. The system generally comprises of multistory combinations of trees and crops and integrating the animal components. The objectives of growing

multipurpose trees are high value of produce, nutritional needs, shade and round the year availability of fruits. These serve the household and domestic needs and also serve the purpose of shade and privacy. The important multipurpose tree species of home garden based agro-forestry system in east coast ecosystems of India are presented in Table 4. In most of the home gardens, the spatial arrangement is irregular but the vertical space arrangement is generally well conceived. The variations in the size of home gardens are generally governed by size of the land holding. The average number of trees in home gardens per family varies from 5 to 6. These home gardens are important for risk minimization, round the year labour utilization, improved nutrition and family income. With systematic evaluation and characterization, the efficiency and output from the home garden based agro-forestry system can be improved.

Agri-horticultural/Agri-horti-silvicultural system for eastern plains

Growing of fruit trees is an important cash cropping practice in Bihar as it is major supplier of fruits in India. The fruit trees take long time to bear fruits and are generally spaced widely. Till they grow and cover the entire land, farmers raise cereals, pulses, vegetables, tubers, medicinal and aromatic plants and fodder in the inter spaces. Papaya and dwarf varieties of banana are also inter cropped depending on the edaphic conditions. With increase in canopy cover of trees, tuber crops are preferred. Improvement in soil conditions through various agronomical practices required for inter cropping helps in improvement of fruit bearing capacity of trees. Under agri-silvi-horticultural systems, farmers often put a trench on the boundary of their orchards and ridge of the trench is planted with multipurpose tree species like *Dalbergia sisoo, Wendlandia exserta, Phoenix sylvestris, Borassus flabellifer, Tectona grandis* etc. These trees protect the orchard from high velocity wind and dessicating heat and provide fuel, fodder and timber to the farmers. The inter spaces of orchards are utilized by cultivating crops. Litchi is a major commercial crop in Bihar. Growing a number of other crops in association with litchi plantation is a widespread practice in all litchi growing areas. Yield of inter crops under two cropping patterns viz. paddy-wheat-greengram-ginger and maize-toria-green gram-pointed gourd was studied across an age series of litchi plantations during 1-9 years following planting. There was marked reduction in yield of all inter crops with increase in age of the plantation. In first cropping pattern, paddy, wheat, green gram were cultivated till 6 years of planting followed by shade loving ginger crop up to 8 years of planting. In second cropping pattern, maize, toria and green gram were cultivated up to five years of planting followed by pointed gourd up to 8 years of planting. The benefit : cost ratio of inter crops and fruits after 9th year of planting in cropping pattern I and II were 2.17 and 2.73, respectively. On a 9 year cycle of litchi orchard, establishment, management and harvest of fruits and intercultural operations of inter crops generate employment opportunities of 130-140 mandays per ha per year (Chaturvedi and Jha, 1998). Under Eastern UP conditions, agrisilvihorti culture system has been found to be promising. In this system fruit species like aonla, guava and ber are planted in association with Casuarina and Eucalyptus hybrids separately. Agricultural crops are grown between rows of tree species. It has been observed that agricultural crops perform better under casuarin as based system than eucalyptus based system. Later on due to increase in canopy of tree and fruit species, tuber crops like colocasia and turmeric

Table 4. Important multipurpose tree species of home garden based agro-forestry system in east coast ecosystems of India

Important species	Utility						
	Fruit	Fuel wood	Fodder	Shade	Live fence	Timber	Miscellaneous
Mangifera indica	√	√		√		√	
Tamarindus indica	√	√		√		√	
Artocarpus heterophyllus	√	√		√		√	
Pongamia pinnata		√			√	√	Oil and cake
Dendrocalamus strictus		√	√		√	√	
Psidium guajava	√	√				√	
Musa spp.	√		√				
Carica papaya	√						
Caryota urens							Country liquor (tadi)
Syzygium cuminii	√	√	√	√		√	
Bombax ceiba							Fibre
Ficus religiosa			√	√			Religious
Bixa orellana							Edible dye (butter)
Erythrina indica					√		Nutrient recycling

are cultivated. The casurina based system shows tuber yields of 3 t ha^{-1} and 1.5 t ha^{-1} for colocasi and turmeric, respectively.

Low cost rain water harvesting for establishment of fruit orchards in plateau region

The technique on *Doba* has been standardised for storage of runoff water under upland conditions. The technology involves digging of pit of size 3.0 m x 1.5 m x 1.0 m in uplands and lining the pits with UV-stabilized black polythene (250 micron). After collection of rainwater in the *Doba* in the rainy season, the pit has to be covered with thatch made out of locally available material. It has been estimated that one *Doba* is sufficient for storage of rainwater for providing lifesaving irrigation to 10 newly planted fruit saplings. The structure has a life span of 2 years. The structure can also be used for storage of water from seasonal streams for establishment of fruit trees.

Use of plastic mulching in vegetable crops

The technology involves covering the soil with LLDPE plastic sheet (bicolor) of thickness 50 micron and sowing of seeds of vegetable crops at holes made at recommended spacings. The mulch material are held tight without any crease and laid on the bed. The

borders (10 cm) are anchored inside the soil in about 7-10 cm deep in small furrows at an angle of 45°. Seeds are sown directly through the holes made on the mulch film. In case of transplanted crops, the seedlings could be planted directly into the hole. About 26 to 60% increase has been recorded in yield of different vegetables in case of mulched field over that of unmulched field. In drip irrigation the lateral pipelines are laid under the mulch film. In case of cucurbits, sowing the seeds in December and covering the soil with white transparent mulches helps in hastening seed germination. Covering the newly emerged plants with white transparent polythene tunnel result in increased plant growth due to prevailing higher temperature inside the tunnel. This helps in early harvest of crop than the traditional methods.

Drip irrigation of vegetable crops

Drip Irrigation involves technology for irrigating plants at the root zone through drippers fitted on a network of pipes (mains, sub-mains and laterals). The drippers are designed to discharge water at prescribed rates. Generally, 30-70% of the area is wetted dependent upon plant spacing, nature and development of root zone. Its advantages are in terms of savings of water (50-60%) of that required for flow irrigation, effective use of fertilizers, less labour and energy cost. About 40-60% increase in yield over that of flood irrigation has been obtained in different vegetable crops. For small holders, use of drip irrigation through drum kit system has been found to be very effective in vegetable crops. The technique of subsurface drip irrigation involves laying out of lateral pipes in the sub-surface zone in order to apply water at root zone. The system helps in minimization of evaporative loss of water. In cucurbitaceous vegetables, 11% yield advantage has been obtained over surface drip by placing the laterals at a depth of 10cm in the soil.

Plant protection measures

Integrated management of bacterial wilt of tomato/ brinjal in alfisol

Bacterial wilt (*Ralstonia solanacearum*) is a serious problem in solanaceaous vegetables grown under alfisol which cause severe losses in yield particularly during the rainy season. The pathogen survives in soil for longer time and it is very difficult to manage it in field. Combined application of Farm Yard Manure (FYM) @ 30 q ha^{-1}, green manure @ 120 kg/ ha^{-1} seed sowing of *Sesbania* sp., PGPR @ 5 kg ha^{-1} soil application, PGPR root dipping @ 1%, Liming @ 25 q ha^{-1}, Karanj (*Pongamia*) cake @ 10 q ha^{-1}, spent mushroom substrate (*Pleurotus s*pp.) @ 10 q ha^{-1} in bacterial wilt resistant varities of tomato is most effective for reduction of bacterial propagules and wilting percentage. The technique can result in increase in yield of tomato.

Inter-generic grafting of solanaceous vegetables

Susceptibility of high yielding F_1 hybrids of solanaceous vegetables like tomato, brinjal, capsicum to bacterial wilt prevent their cultivation during rainy season. The available bacterial wilt resistant varieties of tomato and brinjal can be used as rootstock to prevent mortality during rainy season. The steps involved for preparing the grafted plants are selection of root stock of 15-20 days old seedling, selection of Scion of 15-20 days old seedling, cut the brinjal above cotyledons at 30° angle, slide 10 mm long latex tube (cut at 30° angle) on brinjal, cut tomato stem above cotyledons at 30° angle, slide tomato stem into tube.

Technique of inter-generic grafting

Performance of grafted tomato plants

Management of guava wilt

Application of 5 kg of Kalisena treated FYM prepared by mixing 1 kg of *Kalisena* S.L. (formulation of *Aspergillus niger* developed at IARI, New Delhi) with 200 kg FYM per pit at the time of planting result in reduction on mortality of guava plants due to wilt.

Pheromone trap for control of fruit fly of mango

The technology involves overnight drenching of wooden block of size 5 x 5 cm made out of plywood in solution prepared by mixing Ethanol, methyl eugenol and malathion at a ratio of 6:4:1. Ten drenched wooden blocks can be nailed or tied in mango plants in 1 ha of area. The pheromone trap should be tied in the plant in the first week of April.

Dead male insects in of fruit fly in methyl eugenol trap

Increasing survival of newly planted mango plants under plateau conditions

The technology involves steps like use of appropriate planting material with high root : shoot ratio, application of Trichoderma treated FYM @ 5 kg per pit at the time of planting of mango, winter protection through thatching, irrigation and inter cropping.

Management of shoot gall psylla in mango

Shoot gall psylla, a serious pest of mango could be effectively managed with three sprays of quinalphos (0.05%) starting from 1st week of August followed by 3 application of 2, 4-D (80 ppm) starting from gall appearance stage at 10 days interval.

Management of powdery mildew in vegetable

Powdery mildew in pea caused by *Erysiphe pisi* could be managed by pre-ponement of sowing date in September and October. The disease could be controlled by spraying calexin (0.05%).

Powdery mildew of cucumber caused by *Erysiphe chichoracearum* could be controlled by spraying karathane 0.1% and powdery mildew of bottle gourd caused by *Sphaerotheca fuligena* could be controlled by spraying Topsin M-70 (0.1%).

Technology options for processing of fruits and vegetables

Freezing: Frozen fruits and vegetables are now becoming popular among consumers. Freezing is a fairly widespread technology causes minimal changes in the shape, texture, flavor and color of foods. Vegetables are generally frozen subsequent to blanching, while fruit can be frozen either in a fresh state or in syrup. Many fruits and vegetables will retain good quality for up to 12 months, when stored at temperatures of -18ºC. The keeping quality of frozen products is, however, dependent on their storage conditions. Energy requirements for freezing operations are high and thus the cost of this technology and the storage of its products are high.

Thermal Processing: Thermal processing technology is applied for the shelf-stable preservation of fruits and vegetables. Thermal processing can be carried out at a range of technical levels, from the cottage through to the industrial level, and is widely applied in the production of jams, jellies and canned, and bottled fruits and vegetables. Recent developments in thermal processing technologies include the use of aseptic processing which make use of sterile laminated packaging.

Drying Technology: Preservation of food by drying is an age old method. Drying technologies applied in fruit and vegetable preservation range from simple and appropriate technologies such as sun and solar drying to state of the art technologies such as freeze drying, drum drying, fluidized bed drying and spray drying. Dried fruit and vegetable products have the advantage of reduced weight and reduced transportation cost. Many of the conventional drying techniques applied in the preservation of fruits and vegetables lead to losses in nutritional value, color, flavor, aroma and texture.

Dehydrated garlic powder, coriander leaf, ginger powder

Osmotic dehydration: Osmotic dehydration treatments are based on the principle of osmosis. These processes essentially involve introducing the fruit or vegetable into an aqueous solution of salt or sugar of increased osmotic pressure where its tissue is impregnated

with the solute. They can be further dried in hot air for bringing down the moisture at safe level. The quality of dried fruits by this technology is found superior.

Fermentation: Fermentation is the slow bio-conservation process of foods induced by microorganisms or by enzymes of microbial, plant or animal origin. It is one of the oldest forms of processing technologies for food preservation. Fermentation technologies in developing countries have evolved through years of experience rather than through scientific breakthroughs. A variety of fruits and vegetables are preserved by fermentation methods.

Minimal Processing: Now a day, minimally processed foods are becoming very popular among urban masses. Minimal processing employs an integrated approach wherein the handling, processing, packaging and distribution of raw fruits and vegetables is properly managed with the application of appropriate food safety principles of Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP).

Non-Thermal Processing Technologies: This technology is relatively newer than the above technologies. This type of processing involves a number of non-thermal physical processes such as high intensity pulsed electric fields, high intensity pulsed light, high hydrostatic pressure and food irradiation offer considerable potential for future use in the minimal processing of fruits and vegetables. The high cost of many of these technologies limits their application in many countries.

Research Support in Horticulture in the Eastern Region

The region receives research back ups from nine State Agriculture Universities viz., Narendra Dev University of Agriculture and Technology, Faizabad, Rajendra Agriculture University, Pusa, Bihar Agriculture University, Sabour, Birsa Agricultural University, Ranchi, Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani, Uttar Banga Krishi Vishwa Vidyalaya, Cooch Behar, Assam Agriculture University, Jorhat, Odisha University of Agriculture and Technology, Bhubaneswar and Indira Gandhi Krishi Vishwa Vidyalaya, Raipur and ICAR Research Institutes/Centres like ICAR Research Complex for Eastern Region, Patna, National Research Centre for Litchi, Muzaffarpur, Central Potato Research Station, Patna, Central Tuber Crop Research Institute Regional Station, Central Horticultural Experiment Station, Project Directorate on Water Management, Project Directorate on Women in Agriculture and State funded units viz., Regional Plant Resource Centre, Bhubaneswar. Apart from Department of Agriculture in different states, the region also has support of 171 numbers of Krishi Vigyan Kendras for undertaking extension activities in the field of horticulture.

Post Harvest Management of Horticulturral Crops

The eastern region produces fruits and vegetables to the tune of 13.4 million tones and 64.2 million tones, respectively. It has been estimated that 37% of our highly perishable horticulture produces are wasted due to lack of post harvest management and cold chain infrastructure which account for an annual loss of 28 million tones approximately. At present, the available surplus of vegetables in eastern India is approximately 22 million tones keeping in view the minimum dietary requirement of population of eastern Indian

states. Since eastern India contributes nearly 48% of total vegetable production in the country, it has strategic importance to fulfill the requirement of vegetables in other parts of India. Hence, it is the need of the hour to strengthen the infrastructure for post harvest management of horticultural crops in eastern India to augment forward marketing.

Current status of post harvest management

At present, a total of 1504 number of cold storage units are available in different states of eastern India with a total storage capacity of nearly 11.2 million tonnes. However facilities on cool chain are still at its infancy in this region. With respect to processing sector, a total of 620 numbers of food processing units are available in eastern India with a majority of small and cottage level. The ideal storage conditions needed for different horticultural produce have already been standardized which can be immediately implemented in view to reduce the losses after harvest. The region has the strength at large in the area of post harvest management with surplus unskilled manpower that can be effectively utilized in the post harvest management sector after their capacity building through training.

In most parts of the eastern region, there is no organized collection and distribution for the fruits, vegetables and other horticultural commodity. The produce is collected by small traders in the farm sites/ local markets/ forest produce in hats, which are then transported to cities or large markets using gunny bags packing and local transport systems. There the big traders collect the materials and own the subsequent business. There is almost no primary sorting/ grading in the farm and the farmers are often forced to sell the commodity at a throw away price. The transportation of the commodities from the rural areas to urban markets is often by small trucks without taking precaution for the heat and mechanical damage during transportation. Major infrastructural limitations also continue to impose severe constraints to domestic distributions well as to the export of horticultural produce. Considerable waste occurs owing to the fact that small farmers lack of knowledge and resources; and are unable to market their produce and implement suitable postharvest handling practices. Spoilage of fresh produce is also accelerated by the hot and humid climate of the region. For example, Litchi, Mango, Sapota etc are the produce of summer facing more the 40^{o}C temperature. Postharvest management and processing of horticultural produce has assumed considerable significance in light of increasing demand for fruits and vegetables in the region. It should only be celebrated that the high production of fruits and vegetables is of significance only when they reach the consumer in good condition and at a reasonable price, so that farmers can get better return of their produce. Urgent efforts are needed to integrate horticultural production with postharvest management since

Mahua and tamarind cleaning and sale in local hat of Jharkhand

postharvest loss reduction and utilization have considerable bearing on food availability. It is established fact that food loss reduction is normally less costly than equivalent increases in food production. Reduction of postharvest losses is essential in increasing food availability from existing production. The success of production lies in the proper distribution of produce and its subsequent utilization by the consumer with zero waste.

Strategies for minimization of post harvest loss of horticultural produce

The major constraints which contribute to low or negligible processing of horticultural crops in eastern region are as follows:

- Poor post harvest management facility
- Inadequate market support
- Unavailability of processing infrastructure
- Inadequate capital flow in establishment of infrastructure
- Lack of awareness about horticultural potentiality of the region

For development of post harvest management sector in eastern region there is a need for paradigm shift from 'higher production → Market glut → Need for processing' approach to 'Demand driven production → Targeted utilization' approach. For achieving this paradigm shift, there is a need for adoption of a two pronged strategy.

Strengthening cottage industries in rural area

Skill development of available manpower and technological up-gradation of cottage industries on post harvest management and food processing for quality control in form of availing modern machineries for small-scale processing will go a long way in strengthening of processing sectors in eastern India. However, the competitiveness of the rural cottage industries in the market, there will be need of involvement of marketing professionals for manufactured product promotion. Public awareness campaigns must be implemented in order to increase awareness of the costs and implication of losses after harvest. Fixed targets must also be established to curb post harvest losses, along the same lines as those used in other time bound national programs. Public awareness campaigns should involve scientists, as well as extension and social worker organizations, and should incorporate the use of audio visual aids and the mass communication systems, including both print and electronic media.

For ensuring continuous and sufficient supply of raw material to the processing units, it would be appropriate to formulate a strategy for :

Exploiting available raw material and infrastructure for processing and value addition

(a) Primary processing of the produce and forward linkages with the main units

- Mobile primary processing vans for highly perishable - Tomatoes
- Mobile collection van from primary market – Mango, Ginger, tamarind, pear, Jamun, papaya, guava, beans, peas, chillies, cabbage, cauliflower and carrot etc.
- Refrigerated collection vans for delicate produce like Litchi. Mango, Mushroom& Strawberry

- Jack fruit peeling, slicing, blanching and refrigerated transportation van
- Promotion of Service Centers at Village *Hat* level
- Forward linkages with the main processing and marketing units

(b) Processing and product development

- Processing unit for tomato pulp and sauces
- Pulping of different fruits and vegetables and manufacturing of juices and RTS, Soups and Sacuces
- Slicing and canning units for different fruits, vegetables and mushrooms
- Drying and packaging units for ber, tamarind, mahua, chironji etc.
- Minimal processing of fruits and vegetables for organized marketing

Establishing newer area of production and processing industries

The food processing sector is employment driven and it is considered that an investment of ₹ 1000 crores can provide employment to 54,000 persons in that industry. The proper marketing of fruits and vegetables from the areas of abundance to places of scarcity will stabilize fruit and vegetable prices. Proper postharvest management practices for minimizing losses and for improving marketing are generally not followed eastern region of India.

Contract farming in potential zones

The eastern region has vast tract of land that remain unutilized, which can be used for targeted production of horticultural crops to cater exclusively to the requirement of processing industries in this region. Expansion of area under the targeted crops should be promoted through contract farming with involvement of corporate sector. The supply of desirable raw materials for processing is key of the success of processing units and the quality of the processed products.

Establishment of processing units in targeted areas : The region produces nearly 22 million tones of surplus vegetables. A sizable part of it can be processed into different value added product. Similar is the case with fruits also, where a large quantity of produce could not be harvested/collected/utilized particularly from forest areas. If all such products are utilized for processing (Table 5), this will not only regulate the market but create job opportunity in the region. With proper quality control, the processed products can be a good source of foreign exchange earnings for the region. At present, India exports around 0.8 million tones of processed food products worth ₹ 1830 crores, with a meager share in the world market. Hence, there lies enormous scope of profit maximization in this sector.

There is a need for Product branding and market development by establishment of Growers and Processors Associations with strong linkages with SHGs and NGOs. The branding of products can be done in the line of other successful brands like MAHAGRAPE, MAHAMANGO, KANDHMALS TURMERIC (Odisha). For strengthening of marketing support, establishment of linkage with Marketing Boards will be highly essential.

Infrastructure on post-harvest handling

This sector constitutes the major weakness of the Eastern region. Horticultural commodities being perishable are vulnerable to high losses after harvest, till these reach

Table 5. Availability of horticultural produce for processing in the eastern region

Fruits/ Vegetables	Availability period	Processing methodology	Processed product
Aonla	October - January	Pulping, Drying, segmentation and shredding	Chawanpras, Preserve, Candy, Beverage, Jam, Pickle and Dehydrated fruits
Mango	March - August	Pulping, Drying and pickling	Pickle, Beverage, Pulp, Pectin from peel, Kernal powder
Guava	August - February	Pulping	Jelly, Beverage, Toffee/ leather
Jack fruit	February - July	Canning, drying and pickling	Dried flakes, Pickle, Canned, Roasted seed
Pear	June - August	Canning and pulping	Jam, Slice, Canned fruits
Custard apple	September- October	Pulping and freeze drying	Custard paste, Dried custard pulp powder
Tamarind	April - May	Pulping, dying and kernel processing	Dehydrated pods, Pulp, Kernel powder
Bael	March - May	Pulping and slicing	Beverage, Preserve, Slice
Tomato	November - June	Pulping, drying	Ketchup, Puree, Pulp, soups
French bean	September-December	Canning	Canned beans, Pickle
Cauliflower	Round the year	Freeze drying and pickling	Canned, Dehydrated, Pickle
Cabbage	September - May	Freeze drying, canning	Canned, Dehydrated, Sauerkraut
Pea	December - April	Canning	Canned peas
Elephant Foot Yam	August - December	Slicing and pickling, drying	Pickle
Lime and lemon	February-December	Pickling, juice extraction	Pickle, Beverage, Marmalade
Mushroom	Round the year	Pickle, Canning and drying	Canned and dehydrated products like soups

the consumer. Depending upon crops and season of harvest, estimated losses range from 8-37%, resulting in annual loss of more than ₹ 10,000 crores in the country. These losses are much higher in Eastern India owing to poor post harvest handling infrastructure, unreliable transportation system and inadequate road network. For effective marketing of perishables like fruits and vegetables, adequate infrastructure for marketing of the produce is important. The existing number of wholesale markets in different eastern states (Table 6).

Table 6. Number of Agricultural Produce Marketing Centres in different states of eastern India

State	Number
Assam	113
Bihar	306
Chhatisgarh	154
Jharkhand	219
Odisha	399
Eastern UP	178
West Bengal	489

Source: www.agmarknet.nic.in

With respect to infrastructure for processing, a total of 620 number of units for processing of fruits and vegetables are present in eastern India as compared to a total of 5166 numbers at all India level (www.agmarknet.nic.in). Among all the eastern states, the maximum number

of processing units is present in the state of West Bengal (308) followed by Eastern UP (170). Data on available cold storage facilities in different eastern states is given in Table 7. A total of 1504 number of cold storages are available in eastern India compared to 5381 numbers at national level (27.95%). However, eastern India has 46.05% of total storage capacity at national level. Among the different eastern states, Eastern UP has the maximum number of cold storage units (556) whereas West Bengal has the maximum storage capacity (5682000 MT).

Table 7. Sector-wise distribution of cold storage in eastern India

State	Private Sector		Cooperative		Public Sector		Total number	Total capacity in MTs Capacity
	No.	Capacity	No.	Capacity	No.	Capacity		
Assam	19	85948	1	1000	4	1120	24	88068
Bihar	236	1100641	10	46400	0	0	246	1147041
Chhatisgarh	67	341815	1	29	1	41	69	341885
Jharkhand	37	142733	8	27415	0	0	45	170148
Odisha	81	248739	16	38100	4	4200	101	291039
Eastern UP	526	3444700	29	96600	0	0	556	3541300
West Bengal	413	5380000	50	302000	0	0	463	5682000
Eastern India	1379	10744576	115	511544	9	5361	1504	11261481
India	4885	23406745	356	936865	140	107042	5381	24450652

Source: www.agmarknet.nic.in

Constraints and Strategies for Horticulture Development in Eastern Region

Horticultural crop based production system provide an efficient alternative for increasing the profitability of agriculture production system by effective utilization of natural resources. Planning Commission Working Group on Horticulture Crops, plantation crops and Organic farming for the XI Plan had attempted to redefine the phrase 'Horticulture' as "the science of growing and management of fruits, vegetables including tubers, ornamental, aromatic and medicinal crops, spices, plantation crops and their processing, value addition and marketing". The region is endowed with climatic conditions for successful cultivation of large number of horticultural crops. Horticulture and Plantation Sector has received focused attention in our planning process from VII five year plan period onwards; as a result, there has not only been sustained increase in production of horticulture and plantation crops but hi-tech horticulture has also been recognized as a commercial proposition. It is a fact that horticulture and plantation sector has provided opportunity of crop diversification, resulting into increased income from the land and also the nutrition security. The benefit of area expansion in horticulture in clusters supported by post harvest management infrastructure has percolated down to even small and marginal farmers a number of whom contribute to exports of horticulture produce too. However, the wide array of constraints prevailing under the eastern region limit growth of horticulture sector.

Broadly the edaphic constraints in the region are listed below.

- Low size of holding preventing introduction of improved production technologies like farm mechanization. Per capita availability of net cultivated land in the eastern

region is lowest in the country. About 68% of the farm holdings are marginal to small ranging from 0.3 to 0.5 ha.

- Soil acidity problem exist to a considerable extent in Chhattisgarh, Jharkhand and Assam.
- Coastal soil salinity is also a problem in the states of West Bengal and Odisha.
- Substantial area in the eastern region is also categorized as water congested or waterlogged where water remains stagnated for a longer durations.

For enumeration of specific constraints in different parts of eastern region, the entire eastern region can be geographically divided into (a) Hilly, terai and plateau region, (b) Middle and lower gangetic plain, and (c) Coastal region

Specific constraints of hilly, terai and plateau region

Edaphological constraints

The slopy land in the region is the major contributing factor towards soil erosion and shallow depth of soil. Apart from this, crusting of surface soil after rainfall, low content of organic matter in the soil, low availability of nitrogen due to leaching and low availability of phosphorus due to fixation of phosphorus forming compounds are some of the major factor for low productivity of different crops in the region. Toxicity of iron and aluminum and deficiency of Calcium, Magnesium, sulphur, boron, Zinc and molybdenum also contribute towards edaphological constraints in the region.

Climatological constraints

High rainfall combined with high rate of leaching of nutrients has resulted in increase in soil acidity and higher accumulation of aluminum in the soil. Less number of sunny days, low temperature, persistent winter prevent successful cultivation of a number of horticultural crops like grapes, pomegranate etc. Hail storm during spring and summer season result in severe damage to both fruit and vegetable crops. Low rate of success of plant multiplication due to prevailing low humidity and temperature in this zone is also a major constraint for expansion of area under horticultural crops.

Biotic constraints

Hopper, shoot gall psylla, fruit fly, powdery mildew, anthracnose in mango, mite of litchi, wilt of guava, shoot and fruit borer in brinjal, powdery mildew in cucurbits, wilt of solanaceous vegetables, termite attack, rhizome rot in ginger are the major biotic constraints of horticultural crops in the region.

Developmental constraints

Unavailability of irrigation source (less than 21% of cultivated area is under irrigation), low level of fertilizer use (65.73 kg ha^{-1} of $N+P_2O_5+K_2O$), inadequate availability of seed and planting material of different horticultural crops and economic backwardness of farmers are the major developmental constraints of the region.

Technological inadequacy

There is a need for development of technologies on location specific soil and water conservation models, suitable varieties of different fruit crops, package of practice for cultivation of makhana under Chhatisgarh conditions, suitable varieties of tuber crops such as Colocasia, Elephant foot yam, cassava, diversification options in horticultural crops, amelioration of multinutrient deficiency, package of practices for horticulture based production system particularly high density planting system under rainfed conditions, package of practices for off season vegetable cultivation, package for *in situ* orchard establishment under rainfed conditions, integrated nutrient management strategies for different horticultural crops, protocol for organic farming in horticultural crops, biomulches for vegetable crops, collection, characterization and evaluation of lesser known wild crops

Specific constraints of plain region of eastern India

Edaphological constraint

A large tract of this region remain inundated for a considerable period which is a major constraint for growing most of the horticultural crops in the region. Low availability of phosphorus due to formation of calcium phosphate, soil sodicity and deficiency of micro nutrients like iron, manganese, zinc, copper and boron are other edaphological constraints for horticulture development in the region.

Climatological constraint

Hot desiccating Westerly winds during summer season result in heavy damage to fruit crops like litchi.

Biotic constraint

Sudden dying of mango plants, fruit drop in coconut, panama wilt in banana, powdery mildew and hopper in mango, fruit and shoot borer, mite and fruit cracking in litchi are the major biotic constraints of horticultural crops in the region.

Developmental constraints

Small size of holding (77.6% of total number of holdings are marginal in size) is one of the major constraint for introduction of modern horticultural technologies involving farm mechanization. Poor infrastructure development such as rural road and electricity supply and inadequate post harvest handling facilities and poor market support etc. does not enable growers to fetch remunerative price for their produce.

Technological inadequacy

There is urgent need for introduction of improved technologies like micro- irrigation and fertigation in horticultural crops, use of bio regulator to manipulate the growth and development process in fruit crops to streamline the production, INM strategies for different horticultural crops, inter crop prescription for different fruit crops and protected cultivation of high value low volume crops.

Specific constraints of coastal region of eastern India

Edaphological constraints

Soil salinity resulting in formation of salt encrustation, deficiency of nitrogen, available phosphorus and micro nutrients like iron, manganese, zinc, copper, boron and impeded drainage are major edaphic constraints in horticultural crops in the region.

Climatological constraints

Natural calamities like cyclone and flood

Biological constraint

Low efficiency of fertilizers, powdery mildew and fruit fly in mango, bunchy top in banana wilt of solanaceous crops, fruit and shoot borer in brinjal, thripe in chilly, Germplasm erosion due to cyclone are the major biological constraints of the region.

Developmental constraints

Low level of input use and economic backwardness of farmers

Technological inadequacy

There is urgent need for large scale popularization of horticultural technologies like improved varieties of fruit crops like mango, banana etc for local consumption as well as for export, Coconut based land use, salt tolerant varieties of different horticultural crops, utilization of water logged areas by introduction of water chestnut

Apart from the region specific constraints, some of the common constraints of all the three regions that affect growth of horticulture sector in eastern India are

- There has been main thrust on Area Expansion Programmes which lack proper backward linkage with supply of quality seeds & planting materials
- Poor infrastructure, roads, communication, power supply, storage, processing and marketing facilities for agricultural produce.
- Unavailability of timely and adequate irrigation water and improper use of agricultural inputs in irrigated plains.
- Inadequate extension and other service delivery mechanisms (ICTs).
- Low level of adoption of technologies.
- Poor pooling of expertise and resources.
- Absence of effective value chain management.
- Inadequate alliances, partnerships and linkages for research and development, technology dissemination and commercialization.
- Poor credit support in the horticulture sector.
- Lack of authentic and accurate database on horticulture.
- Inadequate market support.
- Poor post harvest management and weak processing infrastructure.
- Inadequate capital flow.

Strategies for horticulture development

Plains of Eastern UP, Bihar, West Bengal, Assam

The region is cursed with flood problem which can be partly mitigated by cultivation of water chest nut and makhana. Flood plains also provide very good condition for cultivation of rainfed melons and other cucurbits. Identification of fruit belts in different areas and further intensification of cultivation hold promise for promotion of export of horticultural commodities from this region. Uttar Pradesh is the first state which has taken initiative in declaring fruit belts in specific areas of specific crop. Similarly, fruit belts can be identified in the eastern regions for extensive area expansion and intensive cropping and promotion of Agro-based industries. Setting up of Agri Export Zone (Litchi) at Muzaffarpur in Bihar and AEZ (Mango) at Malda in West Bengal have given further fillip for the development of horticulture. Besides fruits and vegetables, spices like turmeric, chilies, ginger etc. and different medicinal plants offer ample scope for commercial exploitation. Steps should be taken to ensure supply of high quality seeds to the cultivators. Several areas in this region are humid to par humid. These areas can be exploited for setting up of new commercial nurseries. Strengthening and modernization of nurseries existing in the plains of West Bengal offer another area of high dividend.

Hilly and Plateau regions of Eastern UP, Jharkhand, West Bengal, Odisha, Chhattisgarh and Assam

Soil of this region is of poor quality, acidic with low nutrient and water retention capacities and deficient in macro and micro nutrients and prone to erosion. Under these situations horticultural crops can provide suitable alternative to the low remunerative and traditionally grown crops like upland paddy and other millets. Apart from the major fruit crops, expansion of area under other crops like litchi, sapota, aonla and custard apple hold promise. High density planting in fruit crops, multi tier cropping system, protected cultivation, organic cultivation, off season vegetable cultivation, cultivation of medicinal and aromatic plants are areas that demand attention of public and corporate sectors. The mild climatic condition of the Chotanagpur plateau region is suitable for commercial cultivation of a number of floriculture crops like roses, Gerbera, gladiolus etc. Horticulture based enterprises such as storage and processing units, commercial floriculture, vegetable and flower seed production, hi tech nursery have tremendous potential in this region.

Coastal plains of West Bengal and Odisha

The region is mostly covered with paddy cultivation during the kharif season. Flooding during the rainy season is the major constraint for growing horticultural crops. In waterlogged area , cultivation water chestnut can be popularized. Fish based horticulture farming system having coconut and banana grown on the raised bund of ponds, are coming up nicely in Coastal Odisha, which can be popularized in a large scale in the other parts of the region. Expansion of area under intensive cultivation of fruit crops like banana, pine apple, mango hold promise. Rejuvenation of old and senile orchards and top working with improved varieties needs to be taken up in a large scale. Besides fruits and vegetables, cultivation of spices like chilies, ginger etc. and different medicinal plants like Sarpgandha,

Sadabahar and ornamental crops like marigold, tuberose in field condition and cactus and tropical orchids under protected condition can be popularized in this region. Steps should be taken to ensure supply of high quality seeds to the cultivators. Setting up of hi tech nurseries in this region as has been done in Regional Plant Resource Centre (RPRC), Bhubaneswar can be highly remunerative. Popularization of micro-irrigation system in coconut growing in the sandy tracts of the coastal area will lead to improved productivity.

Apart from the region specific strategies, some of the recommendations for horticulture development in the entire eastern region are,

- Identification of focus crops for different parts of eastern region and adoption of targeted productivity approach
- Improving accessibility of quality critical inputs like fertilizers, pesticides etc.
- Putting in place a system of accreditation and rating of horticulture nurseries
- The import policy on planting material should ensure the availability of best planting material to Indian farmers aiming enhanced productivity, farm income and export earnings. Seeds and planting materials imported/obtained for use in the country must meet the minimum seed standards of seed health, germination, genetic and physical purity as prescribed. To ensure quality in perennials the process should be legislated.
- Promotion of soil test based integrated nutrient management
- Enhancement of productivity of existing orchards by promoting technology solutions in project mode
- Introducing a system of securing availability of quality seeds and planting materials in a planned manner dovetailing the same with area expansion programmes
- Holistic and sustainable development of rainfed areas based on watershed approach.
- Market orientation of horticultural produce along with post harvest processing, product development and value addition, storage etc.
- There is a need to introduce a system of free passage for fresh horticulture Produce throughout the country.
- The issue of increasing the availability of production and investment credit in eastern India needs to be urgently addressed

Summary

The eastern region of India offers a wide variety of soils, climates and plant genetic biodiversity to support a highly sustainable horticultural crop based cropping system. Its strategic locations in the proximity to International boundaries and seacoasts provide added advantage for International trade. India produces nearly 11 per cent of all the world's vegetables and 15 per cent of all fruits, yet its share in global exports of vegetables is only 1.7% and in fruits a meagre 0.5% and indicates towards vast opportunity for Indian horticulture sector in WTO regime. The eastern region has to play a major role in increasing share of India in world trade of horticulture. Several profitable options in high yielding varieties of fruit, vegetable, ornamental, plantation, medicinal and aromatic plants and spices are available. Similarly, location specific production and protection technologies are also available. These recommendations are now required to be tailored in cropping

system approach for effective land use, market orientation, nutritional security, income in employment generation and to enrich environment. The major constraints faced are inadequate availability of quality seed and planting material, lack of post harvest handling and storage facilities, inadequate capital flow and lack of market support. Strengthening of infrastructure for large scale multiplication of quality seeds and planting material and creation of investor-friendly environment for strengthening value chain of horticultural products will go a long way to bring about remarkable change in the horticulture production scenario in the eastern region. In eastern region, negligible emphasis is being given on safe handling of fresh fruits and vegetables. Developing packing station including sorting, cleaning, grading and packaging will certainly help in reducing the losses enhancing the availability. Horticulture data base also requires to be improved for better planning and implementation. Large scale education of growers for registration of plant biodiversity to safe guard their interest, making them aware of WTO requirements and training on handling and marketing of their produce in distant and international market are urgently required.

References

Chaturvedi, O. P. and Jha, M. K. (1998). Crop production and economics under litchi plantation across 1-9 year of age series in north Bihar, India. *International Tree Crop Journal.* 9: 159-168.

Das, P. K. (1991). Areca nut: Benefits from inter-cropping. The Hindu: Survey of Indian Agriculture. Kasturi and Sons Ltd. National Press, Chennai. pp. 97-101.

Fact Sheet. Bihar National Family Health Survey (2005-06) *_http://202.71.128.172/nihfw/nchrc/sites/default/files/Fact%20Sheet-Bihar-566.pdf*

Fact Sheet. Jharkhand National Family Health Survey (2005-06) *http://202.71.128.172/nihfw/nchrc/index.php?q=content/fact-sheet-all-states-3*

Fact Sheet. Uttar Pradesh National Family Health Survey (2005-06)*_http://202.71.128.172/nihfw/nchrc/index.php?q=content/fact-sheet-all-states-3*

Mahapatra, A. K., Mishra, S., Basak, U. C and Panda, P. C. (2012). Nutrient Analysis of Some Selected Wild Edible Fruits of Deciduous Forests of India: an Explorative Study towards Non Conventional Bio-Nutrition. *Advance Journal of Food Science and Technology* 4(1): 15-21.

Nadagoundar, B. S. (1986). Agroforestry Research Manual (1986). Term Paper, Oxford Forestry Institute, Oxford University, Oxford, Sept., 1986.

Nadagoundar, B. S., Mutanal, S. M. and Hiremath, G. K. (1993). Agro-forestry for the sustainable benefit of the people, upgradation of environment and forests. *Fourteenth Commonwealth Forestry Conference,* Kuala Lumpur, Malaysia, Sep. 13-18.